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(54) IMPROVEMENTS RELATING TO PERCUSSION DRILLS

(71) We, HALIFAX TOOL COMPANY LIMITED a British Company of Southowram, Halifax, HX3 9TW, Yorkshire, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention concerns percussion drills and is especially but not exclusively concerned with percussion drills of the down-the-hole type operated by pressure fluid such as compressed air. The invention is however also applicable to percussion drills of other than the down-the-hole type, being in general applicable to drills in which the blows of a fluid pressure-operated hammer mechanism are transmitted to a drill bit directly or through one or more intermediate lengths of drill steel.

The pneumatically-operated, down-the-hole type of percussion drill comprises a drill body within which a hammer piston is reciprocable by compressed air fed to the drill body via a string of one or more drill tubes connected to the rear end of the drill body, the hammer piston delivering blows upon the rear end of the shank of a bit or of a drill steel, the shank being held in a chuck at the front end of the drill body so as to be capable of limited axial movement with respect thereto whereby the impact of the hammer piston blows upon the drill bit or steel shank is not transmitted to the drill body and thus dissipated uselessly. The hammer piston is reciprocated under the control of a distributor valve which directs compressed air alternately to front and rear cyclinder spaces in the drill body, these cylinder spaces also having exhaust ports for discharge of exhaust air from one cylinder space whilst compressed air is being admitted to the other.

In some designs of these drills, the exhaust ports are in the walls of the drill body and are thus fixed in position with respect to the latter and since, in the usual case, the operation of the distributor valve is controlled by movement of the hammer piston past these exhaust ports, the tendency is for the hammer piston to be reciprocated with maximum efficiency only when its stroke extends between fixed positions in the drill body. However, the forward stroke-end position of the hammer piston is determined by the position of contact between the hammer piston and the drill bit or steel shank and, especially when drilling in soft and broken ground, the drill bit or steel may take up variable positions relative to the drill body by axial movement within the chuck.

If, as is usual, the distributor valve and the exhaust port are so arranged as to provide maximum efficiency when the hammer piston is operational between the stroke limits which exist when the bit or steel is fully loaded and at its rearmost position in the drill body, movement of the bit or steel forwardly relatively to the drill body will cause the stroke of the hammer piston to depart from its ideal extent and location relatively to the drill body and the operation to become less efficient. One of the consequences of this decreases in operational efficiency may be that the hammer piston achieves too high an energy in its forward stroke and delivers an excessive blow to the drill bit shank. Moreover, if the drill bit or steel shank reaches the end of its permitted forward movement with respect to the drill body so that there is a mechanical connection effective between the drill bit or steel and the body, the hammer piston blows may be transmitted to the body and cause damage thereto.

Furthermore, if the hammer piston commences its return, rearward, stroke from a forward position beyond its ideal forward

stroke end, it may be accelerated to a velocity such that it overshoots its rearmost permissible position in the drill body and perhaps deliver a blow on the rear end of the rear cylinder space, causing damage to the piston and/or to the drill body.

Sometimes down-the-hole drills of this general construction have a central tube by means of which flushing fluid is conveyed to flushing fluid passages in the drill bit. In some designs of drills having this central tube, the exhaust ports are provided therein so that the exhaust air is conveyed to the drill bit flushing passages and is used as flushing fluid. However, in most known drills having a central tube with exhaust ports therein the tube is fixed in position with respect to the drill body so that the same operational disadvantages arise from fixed location of the exhaust ports as in the case of those designs in which the exhaust ports are in the wall of the drill body.

It is also common in down-the-hole percussion drills to provide for automatic cut-off of the hammer operation in the event of the drill bit becoming unloaded, e.g. as a result of drilling through broken or faulty ground. A common arrangement is for the drill body to include a rear shock absorber section movable relatively to the remainder of the drill body and connected to the string of drill tubes through which pressure fluid is passed to the drill body, relative movement between the shock absorber section and the remainder of the drill body being effective to operate a shut-off valve when the shock absorber section moves relatively away from the remainder of the drill body as a result of unloading of the bit. In certain drills having this feature, the shut-off valve is in the form of a by-pass valve which opens to starve the distributor valve of fluid by venting the pressure fluid supply to the exhaust ports and/or to drill bit flushing passages.

Similar constructional and operating principles apply to fluid pressure-operated percussion drills of other than the down-the-hole type.

An object of the present invention is to provide improved control means for a percussion drill having a fluid pressure-operated reciprocable hammer piston which delivers blows to the end of a drill bit shank or drill steel shank having limited axial freedom in a drill body, whereby the discussed disadvantages of fixed exhaust port locations are avoided and shut-off valve construction and operation is simplified.

The invention accordingly provides a percussion drill comprising a drill body having a chuck adapted to hold the shank of a drill bit or drill steel for limited axial movement relatively to the drill body, a fluid pressure-operated hammer piston reciprocable in the drill body and adapted to deliver blows to the rear end of a drill bit or drill steel shank held by said chuck, and a central tube within said drill body and adapted to engage a drill bit or drill steel shank held by said chuck and to follow at least to a limited exent axial movement of the said shank in the chuck, said tube having an exhaust outlet and exhaust ports that are positioned to communicate with cylinder spaces in the drill body in accordance with the position of said hammer piston so as to control the reciprocation of the latter.

In preferred embodiments of the invention, the exhaust outlet of said central tube is adapted to communicate with an exhaust passage formed in the shank of a drill bit or drill steel, as the case may be, held in the said chuck this exhaust passage communicating with a bit flushing passage. Alternatively the exhaust outlet of the central tube may communicate with a suitable fluid outlet in the drill body.

Because the exhaust ports in the central tube cooperate with the hammer piston to control the reciprocation thereof, the stroke of the hammer piston within the drill body will be determined by the position of the central tube relatively to the drill body; therefore because the central tube follows the axial movement of a drill bit or drill steel, held in the chuck, relatively to the drill body it is possible to arrange for the hammer piston to operate with maximum efficiency and deliver substantially the same impact upon the shank of the drill bit or drill steel as the case may be, over at least a substantial part of the permitted range of movement of the said shank relatively to the drill body.

The movement of the central tube with the shank of a drill bit or drill steel relatively to the drill body may also be adapted to control a shut-off valve that controls the pressure fluid supply to the hammer piston. Thus it may conveniently be arranged that the shut-off valve responds to forward movement of the said central tube, with the bit or drill steel, to a selected extent to by-pass the hammer piston by venting the pressure fluid supply to the said exhaust outlet.

In a preferred embodiment of the invention, a tubular bush carried by the rear end of the said central tube cooperates with a fixed spigot in such manner that the clearance between the spigot and the bore of the bush varies in accordance with the longitudinal position of the tube within the drill body, the space surrounding this rear end of the tube and the said spigot communicating with the pressure fluid supply to the drill so that as the central tube

moves forwardly the pressure fluid supply is permitted to vent to an increasing extent to the bore of the central tube and thence to the exhaust outlet. Thus, by choice of an appropriate configuration for the said bush and its cooperating spigot, it may be arranged that the opening of this pressure fluid by-pass occurs progressively as the central tube moves forward, whereby the power available to operate the hammer piston is progressively reduced as a bit or drill steel shank held by the chuck moves forwardly relatively to the drill body to a position where the by-pass is open to an extent leaving insufficient power available to continue to operate the hammer piston.

The central tube may be arranged to follow the entire permitted movement of a drill bit or steel held in the chuck or it may have a more limited movement, the central tube being adapted to have a lost-motion connection to the shank of a bit or steel held by the chuck, so as to permit the shank to move more forwardly in the drill body than the tube: with this arrangement, the extra movement of the drill bit or steel when fully unloaded, as compared with the maximum permitted forward movement of the central tube, may be arranged to uncover drain ports in the tube through which liquid accumulations within the front cylinder space may be discharged.

A typical embodiment of the invention as applied to a pneumatically-operated down-the-hole percussion drill will now be described by way of example and with reference to the single Figure of the accompanying drawing, which is a partly schematic axial sectional view of such a drill.

The drill illustrated in the accompanying drawing comprises a body 1 fitted with an internal liner 2 within which a hammer piston 3 is reciprocable. At its front end the drill body 1 is fitted with a detachable chuck 4 which retains the shank 5 of a drill bit 6 provided with flushing fluid passages 7 communicating with an exhaust passage constituted by a central bore 8 in the shank 5. The shank 5 is formed with splines 9 which cooperate with mating splines in the chuck 4 so that torque may be transmitted between the chuck and the drill bit whilst the latter has limited freedom of axial movement within the chuck. At its rear end, the shank has an interrupted peripheral rib 10 constituted by the terminal portions of the splines 9 which are relieved for a distance in front of this rib 10 to provide a circular section length of shank. A diametrally split retaining ring 11 encircles this section of the shank 5, being assembled about this shank section and inserted therewith into the drill body so as to be retained in position to determine the limits of axial freedom of the bit in the chuck by abutment with the rearward ends of the splines 9 or the rib 10.

At the rear end of the liner 2 there is a distributor valve assembly 12 providing on its forward face inlet ports 13 for a rear cylinder space defined by the interior of the liner 2 behind the piston 3; the valve assembly also has lateral ports 14 communicating with longitudinal grooves 15 which in turn communicate with a clearance space 16, between the inner wall of the body 1 and a suitably relieved portion of the liner 2, leading to inlet ports 17 near the front end of the liner. The front end of the piston 3 is of reduced diameter so that the ports 17 in the liner are normally open to a front cylinder space defined by the liner in front of the piston 3 and to the rear of the chuck 4.

The rear face of the distributor valve assembly 12 has an air inlet port 18 leading to an annular chamber 19 surrounding an annular valve plate 20 movable between the forward position shown, in which it provides communication between the chamber 19 and the ports 14 (and thus with the inlet ports 17 of the front cylinder space), and a rearward position in which it provides communication between the chamber 19 and the inlet ports 13 of the rear cylinder space. The valve disc 20 is oscillated between its two positions by changes in the pressure differential between the front and rear cylinder spaces as determined by the position of the piston 3 within the liner 2.

The piston 3 and the valve assembly 12 are both of annular construction and a central tube 21 extends through both the piston and the valve assembly so as to be axially movable with respect to each. The front end of the tube 21 fits in a counterbore at the rear of the central bore 8 of the bit 6 and has a series of drain holes 22 which are normally disposed within the bore 8 as shown.

The central tube 21 is desirably formed of a plastics material of high resilience, low coefficient of friction and density, and has two sets of exhaust ports 23, 24 communicating respectively with the front and rear cylinder spaces when the piston 3 is suitably positioned.

The operation of the illustrated distributor valve assembly 12 and its control by movement of the piston 3 relatively to the exhaust ports 23, 24 is well understood in the art. Thus, with the parts in the position shown the piston 3 covers the front exhaust ports 23 while the valve plate 20 of the assembly 12 directs compressed air to the front cylinder space through the inlet ports 17. The piston is thus caused to

moved rearwardly and in so doing uncovers the ports 23 and covers the ports 24. As a result, the rear cylinder space is sealed so that the moving piston compresses air trapped therein, while air in the front cylinder space is permitted to exhaust into the central tube and so lower the pressure in the front cylinder space. As the piston movement continues, therefore, the pressure at ports 13 of the valve assembly 12 rises above that at ports 14 and causes rearwards movement of the valve plate 20 so as to cut off the ports 17 from the compressed air supply and to direct this instead to the rear cylinder space via inlet ports 13, thereby to cause the piston 3 to be arrested and then impelled forwardly. In like manner, the forward moving piston covers ports 23 and uncovers ports 24 to reverse the pressure differential in the cylinder spaces and return the valve plate 20 to its forward position for repetition of the described operating cycle when the piston has been arrested by impact with the rear end of the shank 5 of the bit 6.

Air exhausted from the cylinder spaces through ports 23 and 24 into the central tube 21 flows to the central bore 8 and thence to the flushing passages 7 of the drill bit 6 to act as flushing fluid to assist in flushing debris from the bore hole and in cooling of the cutting edges of the bit 6.

It will be understood from the foregoing description of the operating cycle of the piston 3 that it is the movement of the piston 3 relatively to the ports 23 and 24 which effects the variations in the pressure differential between the front and rear cylinder spaces to actuate the valve plate 20 of the distributor valve assembly 12. Thus the ports 23 and 24 are so located in the length of the central tube 21 that, when the front end of the latter is fully seated in the counterbore of the bore 8, the piston reciprocates with maximum efficiency to deliver, at the end of each forward stroke, a blow of desired intensity to the rear end of the bit shank 5.

Because the tube 21 is axially movable with respect to the valve assembly 12 it may follow the movement of the bit 6 from the position shown in the drawing towards the fully forward position of the bit in which the rib 10 engages the locking ring 11. Thus, during forward movement of the bit 6 relatively to the drill body 1, the relationship of the ports 23, 24 to the struck end of the bit shank 5 is maintained, thereby relating the stroke of the piston 3 to the position of the shank 5 so as to maintain the operation at maximum efficiency.

However, as the bit 6 moves forwardly relatively to the drill body and permits the piston 3 to perform its stroke between correspondingly advanced positions in the body, the forward stroke end position shifts relatively to the inlet ports 17 in the liner 2. Thus as the forward stroke end position advances, the ports 17 become covered to a progressively increasing extent by the piston leading end at such stroke-end position; the effect of this is to trap air in the front end of the bore, to an increasing extent, as the piston approaches its stroke end position and so produce a pneumatic cushion absorbing some of the piston energy and reducing the impact on the shank 5. The risk of the bit being impelled to the end of its permitted forward motion in the chuck is thus much reduced.

In this embodiment of the invention, the permitted axial movement of the tube 21 is less than that permitted to the bit 6, the difference between the permitted axial movements of the bit 6 and the tube 21 respectively being such that when both have moved forwardly to the maximum permitted extent, the tube 21 is effectively withdrawn from the bore 8 in the bit shank 5 to an extent sufficient just to uncover the drain ports 22 in the tube 21. Such a relative positioning of the parts would normally only be attained with the drill body 1 substantially vertical and suspended by its upper (rear) end and in this attitude any liquid in the front cylinder space would thus be able to drain therefrom via the ports 22 and the bore 8 and passages 7.

In order to ensure that the central tube 21 follows any forward movement of the bit shank 5 within the permitted range of movement of the tube 21, the rear end of the latter is fitted with a bush 25, also conveniently formed of plastics material, having a rear surface 26 exposed to the compressed air supply in an annular chamber 27 upstream of the distributor valve assembly 12. Since the front of the bush 25 is ordinarily exposed only to the approximately atmospheric pressure within the tube 21 there will accordingly be a pressure differential acting on the bush 25 tending to displace the tube 21 forwardly within the drill body 1, so tending to keep the forward end of the tube 21 seated in the counterbore in the rear end of the bit shank 5.

The bush 25 also forms part of a shut-off valve assembly which includes a spigot 28 extending forwardly from a spider ring 29 fitted in an inlet passage 30 in an adapter coupling 31 which is secured to the rear end of the drill body 1 and to which a drill tube supplying compressed air from a suitable surface rig is connected.

The spigot 28 is of plain cylindrical configuration whilst the bush 25 has a bore the front part 32 of which is cylindrical, to

match the spigot 28, and the rear part 33 of which is tapered.

As previously noted, the bit is shown in its rearwardmost position in the drawing and thus the drawing also shows the tube 21 in its rearwardmost position. In this position of the tube 21 the spigot 28 fits within the cylindrical bore portion 32 of the bush 25 and thus seals the bore from the compressed air supply in the chamber 27. However, when the tube 21 moves forwardly with the bit 6 relatively to the drill body 1, the bush 25 is progressively drawn from the spigot 28 until the tip of the spigot 28 commences to enter the tapered section 33 of the bore of the bush. At this point, a leakage path exists for compressed air from the chamber 27 to the tube 21 so that a proportion of the compressed air supplied to the drill by-passes the valve assembly 12 and the cylinder spaces within which the hammer piston 3 operates, reducing the power available to maintain operation of the hammer piston.

Thus although the advance of the central tube 21 with the bit 6 will maintain the relationship of the exhaust ports 23, 24 to the struck end of the bit shank 5 and thus maintain the hammer piston operating with maximum efficiency relatively to the struck end of the bit to make best use of the fluid power available to the hammer, the available power to the hammer will be progressively reduced as the bit 6 and tube 21 conjointly advance beyond a selected position in their permitted forward movement with respect to the drill body 1, until eventually so much air will by-pass the hammer piston by flowing to the tube 21 as to reduce the residual power available to the hammer piston to a level insufficient to maintain operation.

Accordingly, when drilling with the illustrated drill, if the bit 6 moves forwardly relatively to the drill body 1, for example as a result of the intermittent unloading which can occur when drilling in soft or broken ground, the blows delivered to the bit shank will be reduced in intensity and additional air will be supplied to the bore 8 for use as flushing fluid, as is desirable in these circumstances. In the event of the bit 6 breaking through a fault, for instance and so moving to its example forward position, the hammer operation will be interrupted until the drill body 1 has correspondingly advanced in the bore hole and restored the normal load upon the bit, whilst during the interruption of operation of the hammer the compressed air supply will be utilized for flushing the bore hole and preventing jamming of the bit by accumulated debris.

A non-return valve assembly is preferably fitted in the passage 30 to hold air pressure within the drill body and cylinder spaces downstream of the valve when compressed air is not being fed to the drill, e.g. when adding a drill tube to the string connected to the adapter coupling 31, thereby to prevent or reduce backflow of water and/or other debris. Such a non-return valve assembly is espectially desirable in the case of embodiments in which the central tube 8 is not provided with drain ports 22 and is free to follow the entire permitted forward movement of the bit shank 5 in the chuck 4. In the illustrated embodiment, the non-return valve assembly is disposed between the spider ring 29 and the passage 30 comprising a sleeve 34 fitting in an enlargement of the passage 30 and having a flange 35 at its upstream (rear) end formed with a port 36 surrounded on the downstream face of the flange 35 by a raised annular valve seat 37. A poppet valve 38 with a tubular stem 39 is guided on a spigot 40 on the rear face of the spider ring 29 and is urged rearwardly by a spring 41 to close the port 36 when there is insufficient pressure differential acting on the valve 38 to overpower the spring 41.

WHAT WE CLAIM IS:—

1. A percussion drill comprising a drill body having a chuck adapted to hold the shank of a drill bit or drill steel for limited axial movement relatively to the drill body, a fluid pressure-operated hammer piston reciprocable in the drill body and adapted to deliver blows to the rear end of a drill bit or drill steel shank held by said chuck, and a central tube within said drill body and adapted to engage a drill bit or drill steel shank held by said chuck and to follow at least to a limited extent axial movement of the said shank in the chuck, said tube having an exhaust outlet and exhaust ports that are positioned to communicate with cylinder spaces in the drill body in accordance with the position of said hammer piston so as to control the reciprocation of the latter.

2. A percussion drill according to claim 1, wherein the exhaust outlet of said central tube is adapted to communicate with an exhaust passage formed in the shank of a drill bit or drill steel, held in said chuck, that communicates with a bit flushing passage.

3. A percussion drill according to claim 1 or 2, wherein movement of the central tube is adapted to control a shut-off valve that controls the pressure fluid supply to the hammer piston.

4. A percussion drill according to Claim 3, wherein said shut-off valve responds to forward movement of the said central tube to a selected extent to by-pass

the hammer piston by venting the pressure fliud supply to the said exhaust outlet.

5. A percussion drill according to claim 4, wherein a tubular bush carried by the rear end of the said central tube cooperates with a fixed spigot in such manner that the clearance between the spigot and the bore of the bush varies in accordance with the longitudinal position of the tube within the drill body, the space surrounding this rear end of the tube and the said spigot communicating with the pressure fluid supply to the drill so that as the central tube moves forwardly the pressure fluid supply is permitted to vent to an increasing extent to the bore of the central tube and thence to said exhaust outlet.

6. A percussion drill according to any preceding claim, wherein said central tube is adapted to have a lost-motion connection to the shank of a bit or drill steel held by said chuck so as to be free to follow only part of the permitted movement of said shank relatively to the drill body.

7. A percussion drill according to claim 6, wherein movement of the shank of a drill bit or drill steel held by said chuck, relatively to the drill body in response to unloading of the bit, causes relative movement between the said shank and said central tube to uncover drain ports therein.

8. A percussion drill according to any preceding claim, including a non-return valve in a pressure fluid supply passage therein.

9. A percussion drill substantially as described with reference to and as shown in the accompanying drawing.

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1 419 981 COMPLETE SPECIFICATION
1 SHEET This drawing is a reproduction of the Original on a reduced scale.